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Tastes, Skills, and Local Public Goods

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Abstract

This paper offers a framework for analysing optimal club configurations in an economy where different types of labor are complementary in the production of private goods, extending the work of Berglas (1976a). The analysis shows that when labor types are nonessential in production, a homogeneous club configuration may be optimal despite the presence of labor complementarity (the assumption that inputs are essential precluded this outcome in Berglas' model). Homogeneous clubs are likely to be optimal when complementarity is weak or when preferences are substantially different.

Tastes, Skills, and Local Public Goods

by

Jan K. Brueckner*

1. Introduction

In the standard club model, as developed by Buchanan (1965), Berglas (1976b), and Berglas and Pines (1981), efficiency requires that different types of consumers are segregated in homogeneous clubs.[1] This arrangement allows public good levels to be chosen to suit individual preferences. Recognizing that real-world communities are typically heterogeneous, Berglas (1976a) altered the assumptions of the club model in search of more realistic results. He assumed that the private good production process (in which different types of individuals collaborate) exhibits a strong form of labor complementarity, with each type <u>essential</u> for production. Under this assumption, the economy must be organized in mixed clubs if any output is to be produced.

When labor types are complementary but <u>nonessential</u>, the planning problem involves an intriguing trade-off that is obscured by Berglas' formulation. In this situation, homogeneous clubs are viable and the following question arises: Should the planner pursue consumption efficiency by forming homogeneous clubs? Or is the increase in output from labor complementarity so great that mixed clubs should be created despite the consumption inefficiency they entail? The present paper presents a framework for answering this question and derives a number of intuitively-appealing results. It is shown that homogeneous clubs are likely to be optimal when labor complementarity is weak or when preferences differ substantially across groups. In the first case, the output gain from mixing is small, while in the second case, the efficiency loss from mixing is large.

A novel feature of the analytical framework is that the planner is allowed to form "partially-mixed" club configurations, where mixed and homogeneous clubs coexist. This option allows the population makeup of mixed clubs to be chosen to best exploit labor complementarity, with the resultant gains distributed across the entire population via interclub transfers. Berglas considered only "completely-mixed" club configurations, where the entire population resides in mixed clubs.

The current framework is similar to the one used by Brueckner and Lee (1989) to analyse optimal club configurations in the presence of a peer-group effect. With such an effect, one type of individual benefits from the other type's presence in the club (the types might represent weak and strong students, with the public good being education). The consumption inefficiency of mixed clubs is then accompanied by peer-group benefits, inducing a trade-off similar to the one analysed below.

2. The Planning Problem

The economy has two types of individuals, denoted a and b. The a-types comprise a fraction θ of the total population N, with the b-types accounting for a fraction $1 - \theta$. The well-behaved type-a and type-b utility functions, which depend on consumption of a private good x and a public good z, are U(x,z) and V(x,z) respectively. The cost in terms of x of providing public consumption z in a club with population n is given by nC(z), where C is convex.[2] The output of the private good in a club containing n_a a-types and n_b b-types is given by $F(n_a,n_b)$, a function that is concave and homogeneous of degree one. $F(n_a,0) > 0$ and $F(0,n_b) > 0$ hold when inputs are nonessential. Together, constant returns in production and the assumption that public sector costs are proportional to n imply that optimal club sizes are indeterminate. This simplifies the subsequent analysis (similar results can be derived, however, when these assumptions are relaxed).

Initially, the planning problem is set up to allow the coexistence of mixed and homogeneous clubs of both types. Some simplifications are immediately evident once the general problem is posed. Let x^a and x^b denote private-good consumption levels in a mixed club for the two types of individuals and let z denote the mixed club's public good level. Consumption levels are x^{ah} and z^a in a homogeneous type-a club and x^{bh} and z^b in a type-b club. The planning problem can then be written

$$\max \quad U(x^a, z) \tag{1}$$

$$\text{s.t.} \quad V(x^b, z) = v \tag{2}$$

$$U(x^a, z) = U(x^{ah}, z^a) \tag{3}$$

$$V(x^b, z) = V(x^{bh}, z^b) \tag{4}$$

$$\begin{aligned} &\sigma n x^a + (1-\sigma) n x^b + nC(z) - nF(\sigma, 1-\sigma) \\ &\quad + [\theta N - \sigma n)[x^{ah} + C(z^a) - F(1,0)] \\ &\quad + [(1-\theta)N - (1-\sigma)n][x^{bh} + C(z^b) - F(0,1)] = 0 \end{aligned} \tag{5}$$

Note that (3) and (4) are horizontal equity constraints, which require equal utilities between mixed and homogeneous clubs for each type of individual, and that (5) is the economy's resource constraint. In writing (5), exactly one club of each type (mixed, type-a, type-b) is assumed to exist (this is appropriate given that optimal club sizes are indeterminate).[3] The mixed club has population n, and the type-a proportion of its population is equal to σ. The type-a homogeneous club thus contains $\theta N - \sigma n$ people, while the type-b club has population $(1-\theta)N - (1-\sigma)n$. Note that the constant-returns property of F is used in writing (5), and that interclub transfers are allowed. Finally, note that implicit constraints in the problem are $0 \leq \sigma \leq 1$ and $0 \leq n \leq \min\{\theta N/\sigma, (1-\theta)N/(1-\sigma)\}$, which says that the mixed club cannot contain more than the total population of either group.

The problem can be simplified by noting that (5) is linear in n, the mixed-club population. This means that a unique optimum will involve a corner solution for n, with n either equal to zero or $\min\{\theta N/\sigma, (1-\theta)N/(1-\sigma)\}$. This implies that if a mixed club is formed, it must accommodate the entire population of one or both groups. Stated differently, the implication is that only one type of homogeneous club can coexist with a mixed club. Next, note that the optimization problem (1)-(5) with n set equal to zero is the same as the problem with $n = \min\{\theta N/\sigma, (1-\theta)N/(1-\sigma)\}$ and $\sigma = 0$ or $\sigma = 1$ (the mixed club becomes homogeneous in the latter cases). This means that the solution with $n = 0$ is superfluous, with the entire range of possible outcomes generated by setting $n = \min\{\theta N/\sigma, (1-\theta)N/(1-\sigma)\}$ and varying σ over the unit interval. For future reference, let the configuration of homogeneous clubs (which corresponds to $\sigma = 0$ or $\sigma = 1$) be denoted H, and let the configuration containing only a mixed club (which corresponds to $\sigma = \theta$) be denoted CM (for completely mixed). A partially-mixed configuration, where σ is not equal to zero, one, or θ, is denoted PM.

It is useful to solve the optimization problem conditional on σ, and then choose σ optimally in a second stage. In the case where $0 < \sigma < \theta$, for example, a mixed club coexists with a type-a club, and the conditional solution is found by substituting $n = (1-\theta)N/(1-\sigma)$ in (5) and computing first-order conditions for the consumption variables. These lead to the usual Samuelson conditions for the two types of clubs. An analogous procedure is used for other values of σ.

Let $G(\sigma)$ denote the maximal value of the objective function for the problem (1)-(5) conditional on σ. The derivative of this function depends on whether σ is above or below θ. In the region where $\sigma < \theta$, it can be shown using Euler's theorem that the derivative G_σ has the same sign as

$$F_1(\sigma,1-\sigma) - F_1(1,0) - ([x^a + C(z)] - [x^{ah} + C(z^a)]) \tag{6}$$

Similarly, when $\sigma > \theta$, G_σ has the same sign as

$$F_2(0,1) - F_2(\sigma,1-\sigma) - ([x^{bh} + C(z^b)] - [x^b + C(z)]) \tag{7}$$

When $\sigma < \theta$, σ is increased by moving an a-type from the homogeneous type-a club to the mixed club, and (6) gives the resulting change in the economy's net output (output minus consumption). Output changes by $F_1(\sigma,1-\sigma) - F_1(1,0)$, the difference in the type-a marginal products between the clubs, and consumption changes by $[x^a + C(z)] - [x^{ah} + C(z^a)]$. When $\sigma > \theta$, σ is increased by moving a b-type from the mixed to the homogeneous club, and the impact on net output is given by (7).

As individuals leave homogeneous clubs, labor complementarity in the mixed club increases the economy's output while the club's consumption inefficiency raises total consumption. As a result, an increase in σ usually has an indeterminate effect on net output (and thus on welfare). The complementarity effect follows from the inequalities

$$F_1(\sigma,1-\sigma) \geq F_1(\sigma,0) = F_1(1,0) \tag{8}$$

$$F_2(\sigma,1-\sigma) \geq F_2(0,1-\sigma) = F_2(0,1), \tag{9}$$

which are established by noting that $F_{12} \geq 0$ holds and F_1 and F_2 are homogeneous of degree zero under constant returns ((8) and (9) are positive when labor types are strictly complementary).[4] Consumption inefficiency is expressed by the inequalities

$$x^{a} + C(z) \geq x^{ah} + C(z^{a}) \tag{10}$$

$$x^{b} + C(z) \geq x^{bh} + C(z^{b}), \tag{11}$$

which are established by showing that the resource expenditure required to support a given utility level in a mixed club is at least as large as in a homogeneous club.[5]

The relative strengths of labor complementarity and consumption inefficiency determine the desirability of a particular change in σ, and more generally, the location of the optimal σ. Figure 1, which graphs the function $G(\sigma)$, illustrates several possibilities. When G corresponds to the lower solid curve, the loss from consumption inefficiency dominates the gain from labor complementarity, and a configuration of homogeneous clubs (corresponding to σ = 0 or σ = 1) is optimal. When G is represented by the upper or middle solid curves, the gain from complementarity dominates and an interior σ is optimal. While the CM configuration is optimal for the upper curve, the position of the middle curve indicates that a PM configuration with b-types in the homogeneous club is optimal. Note that the value of σ in a PM configuration (which gives the identity of the group partly housed in the homogeneous club) will depend in a complex way on the skewness of isoquants and the properties of preferences.

The optimal σ can be found directly in two polar cases. Suppose first that F is linear, so that the labor types are perfect substitutes. Then (8) and (9) hold as equalities, and given (10) and (11), (6) and (7) are respectively nonpositive and nonnegative. This means that G is nonincreasing on $[0,\theta)$ and nondecreasing on $(\theta,1]$, indicating that the homogeneous H configuration is optimal (that is, H is at least as good as any CM or PM configuration).

Suppose on the other hand that type-a and type-b preferences are identical and the common utility function has the quasi-linear form $x + W(z)$. Then z levels in mixed and homogeneous clubs are identical and $x^a = x^{ah}$ and $x^b = x^{bh}$ must hold to equalize utilities. Eqs. (10) and (11) then hold as equalities, and given (8) and (9), G is nondecreasing on $[0,\theta)$ and nonincreasing on $(\theta,1]$. As a result, the CM configuration is optimal (CM is at least as good as any other configuration).[6]

The preceding discussion shows that homogeneous clubs are optimal (suboptimal) when mixed clubs generate no output gain (no efficiency loss), both natural results. The following propositions establish that these conclusions also hold when the output gain (efficiency loss) from mixing is small. Suppose first that F can be represented by the CES production function $[n_a^{-\rho} + n_b^{-\rho}]^{-1/\rho}$, where $-1 \le \rho < 0$. F is linear when $\rho = -1$, and the elasticity of substitution rises (the isoquants become increasingly curved) as ρ rises toward zero (they intersect the axes in this range, indicating that inputs are nonessential). In writing F in this way, it is assumed that the efficiency units supplied by each labor type increase with ρ in a manner that leaves $F(1,0)$ and $F(0,1)$ constant as ρ rises (this anchors the isoquants while allowing their curvature to change with ρ).[7] This constancy, together with the fact that $F(\sigma,1-\sigma)$ is increasing in ρ when $0 < \sigma < 1$, means that the G function in Figure 1 rises in the interior of the [0,1] interval while remaining fixed at its endpoints as ρ increases (this follows from the envelope theorem). It follows that after starting from a curve like the lower one when $\rho = -1$, the G function eventually reaches a position like that of the dotted curve when ρ is sufficiently large.[8] For ρ below this critical value, H is optimal, while for larger values, some mixed-club configuration is optimal. Summarizing yields

> **Proposition 1**. Under the above assumptions, there exists some ρ^* satisfying $-1 \le \rho^* < 0$ such that H is optimal when $-1 \le \rho \le \rho^*$ and some mixed-club configuration (CM or PM) is optimal when $\rho^* < \rho < 0$.

To derive a parallel result regarding the efficiency loss, suppose that the type-a and type-b utility functions are $x + W(z)$ and $x + \delta W(z)$ respectively, where $\delta \ge 1$ (the b-types are assumed to be higher demanders of z). Furthermore, let the type-b function be rescaled by a multiplicative factor as δ changes so that the welfare achieved in the H configuration remains constant (the endpoints of the G function thus remain fixed as δ changes).[9] Then, using calculations described in Brueckner and Lee (1989), it can be shown that the G function shifts down in the interior of [0,1] as δ increases (welfare falls as preference diversity grows in the mixed club). Reasoning similar to that above then yields

> **Proposition 2**. Under the above assumptions, either a mixed-club configuration (CM or PM) is optimal for all $\delta \ge 1$ or there exists a $\delta^* \ge 1$ such that a mixed-club configuration is optimal when $1 \le \delta \le \delta^*$ and H is optimal when $\delta > \delta^*$.

Note that H never becomes optimal if, starting from a curve like the upper one in Figure 1, the G function stays above its endpoint values somewhere in (0,1) as δ rises (this means that the gain from labor complementarity continues to dominate the efficiency loss as preferences diverge).[10]

Combining the CES and quasi-linear specifications, it can be shown that as preference diversity increases, a higher degree of labor complementarity is needed to justify formation of mixed clubs. Similarly, as labor complementarity increases, a larger dispersion of preferences is needed to justify formation of homogeneous clubs. These statements are formalized as follows:

> **Proposition 3**. Suppose that the assumptions underlying both Propositions 1 and 2 are satisfied. Then ρ^* from Proposition 1 is an increasing function of δ. Similarly, if δ^* from Proposition 2 exists, it is an increasing function of ρ.

For a proof of a similar result, see Brueckner and Lee (1989).[11]

3. Equilibrium

Brueckner and Lee (1989) present an equilibrium analysis for the peer-group model, and the similarity of model structures means that their results apply directly to the present case. Clubs in their model are formed by competitive, utility-taking developers who are able to distinguish individuals by type, and clubs are required to be self-sufficient (this accords with the notion of atomistic ownership). Equilibrium club configurations are shown to be efficient, so that developers mix types only when the peer-group effect is strong enough to warrant such mixing on welfare grounds. An analogous result emerges when the developer model is adapted to the labor-complementarity case.[12]

4. Conclusion

This paper has provided a framework for analysing optimal club configurations in an economy with labor complementarity. While reaffirming Berglas' (1976a) basic insight that complementarity favors formation of mixed clubs, the analysis shows that its presence is not sufficient to make mixing optimal. Homogeneous clubs are likely to be optimal when complementarity is weak or preferences are substantially different.

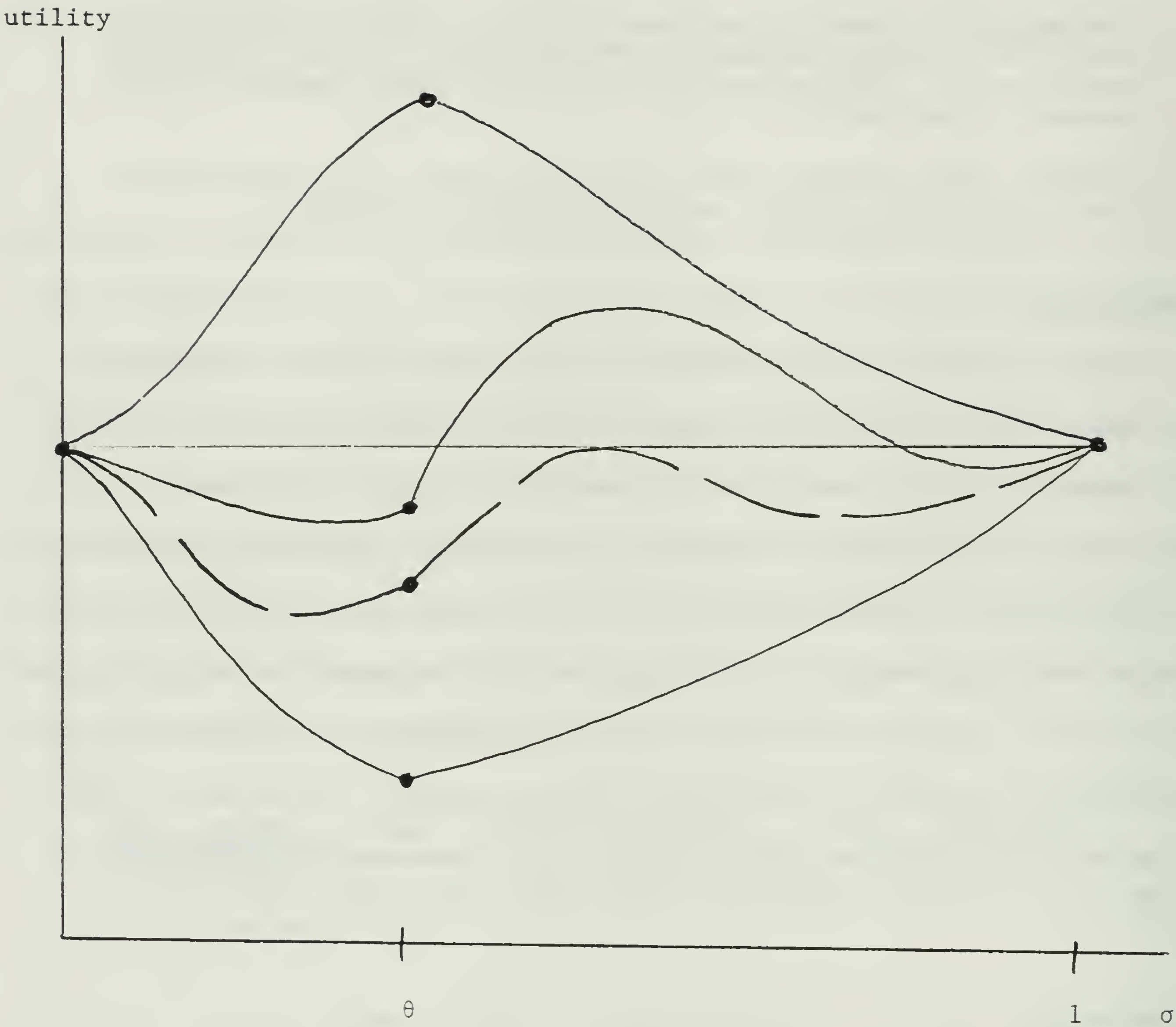

Figure 1 -- The G Function

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Footnotes

*I wish to thank Robert Deacon, Kangoh Lee, and two referees for helpful comments. Any errors are mine. After writing the first version of this paper, I became aware of a related paper by McGuire (1989), which conducts similar analysis using a diagrammatic approach.

[1] For a more recent statement of this result, see Scotchmer and Wooders (1986), who show that mixed and homogeneous clubs may be equivalent under some circumstances.

[2] It should be noted that this public good cost function does not necessarily require that the public good be private. Suppose, for example, that $z = G^{\phi}n^{-\omega}$, where G represents the "size" of the public facility and where $0 < \omega < 1$, and that the cost function for G is $G^{\phi/\omega}$. Public good costs are then $nz^{1/\omega}$.

[3] Note that the indeterminacy of optimal club sizes means that the "integer problem" can be avoided (this problem arises when the population does not fit into optimal-size clubs).

[4] Since the elasticity of substitution equals $F_1F_2/F_{12}F$, strict complementarity (i.e., a finite elasticity) requires $F_{12} > 0$.

[5] Formally, this can be seen by noting that the homogeneous-club Samuelson condition for a b-type guarantees that $x^{bh} + C(z^b)$ is minimized subject to constraint $V(x^{bh},z^b) = v$. Since the mixed-club allocation must satisfy the same utility constraint but is characterized by a different condition (the mixed-club Samuelson condition), (11) must hold. The same argument applies to (10).

[6] It should be noted that a mixed-club configuration (CM or PM) need not be optimal when the common utility function is not quasi-linear. In this case, z levels need not be the same in mixed and homogenous clubs (the Samuelson conditions will be affected by the utility levels of the types), and (10) and (11) may be strictly positive. A more general sufficient condition for the optimality of mixing is that the z levels in homogeneous clubs be equal. In this case, the CM configuration with z held fixed at the common homogeneous-club value is at least as good as the H configuration (at least as much x is available). Additional adjustment of z and σ may raise utility further.

[7] The primitive production function is $[\alpha(e_an_a)^{-\rho} + (1-\alpha)(e_bn_b)^{-\rho}]^{-1/\rho}$, where

e_a and e_b represent efficiency units per worker. It is assumed that $e_a = \alpha^{1/\rho}$ and $e_b = (1-\alpha)^{1/\rho}$.

[8]Mixed-club output increases without bound as ρ approaches zero ($\rho = 0$ is the Cobb-Douglas case).

[9]In other words, V must be rescaled as δ changes so that after satisfying the type-b Samuelson condition and $V(x^{bh}, z^b) = v$, the resources left over for the type-a homogeneous club are invariant to δ.

[10]While the optimal σ generally depends on v (the fixed type-b utility level), the optimum is independent of v in the quasi-linear case. This follows because the multiplier on the constraint (2) is then equal to minus one, indicating that the G function shifts down in a parallel fashion as v increases. This point was suggested by a referee.

[11]The present framework can also be used to show that a completely-mixed configuration need not be optimal when inputs are essential (Berglas (1976a) considered only CM configurations in his model). To see this, suppose that F is Leontief, with output equal to $\min\{\alpha n_a, \beta n_b\}$. Then $F_1 = \alpha$ (0) and $F_2 = 0$ (β) as $\sigma <$ (>) $\eta \equiv \beta/(\alpha+\beta)$. Assuming that $\eta < \theta$, it follows that (6) equals

$$\alpha - ([x^a + C(z)] - [x^{ah} + C(z^a)])$$

for $0 < \sigma < \eta$ and equals

$$-([x^a + C(z)] - [x^{ah} + C(z^a)])$$

for $\eta < \sigma < \theta$. Also, (7) equals

$$-\beta - ([x^{bh} + C(z^b)] - [x^b + C(z)])$$

for $\theta < \sigma < 1$. While the first and third expressions are ambiguous in sign, the second expression is nonpositive, indicating that G is nonincreasing between η and θ (note that output is increasing in σ below η, constant between η and θ, and decreasing in σ above θ). This shows that the PM configuration corresponding to $\sigma = \eta$ is at least as good as the CM configuration (the actual optimum may, of course, lie below η or above θ). Thus, it is optimal in this case to create a zero-output homogeneous club, whose consumption is financed by a transfer from the mixed club.

[12]The adaptation of Brueckner and Lee's developer model to the present framework proceeds as follows. Developers receive the output of the private good, pay public sector costs, and pay the wages of workers. The type-specific wage payments (which depend on the club's public good level) yield

enough private consumption to allow each type of worker to achieve the prevailing utility level for his type. An equilibrium is a pair of utility levels such that profit-maximizing clubs yield zero profit and accommodate the economy's population. This "utility-taking" approach to equilibrium analysis, which follows Berglas (1976b), differs from the "price-taking" approach used by Berglas and Pines (1981) and Scotchmer and Wooders (1986).

It should be noted that while Brueckner and Lee conclude that equilibrium is efficient, they point out that an equilibrium may not exist. Further analysis of their model shows, however, that nonexistence can be ruled out by additional arguments.

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